Computer Simulation of Post-Burn Skin

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Contact person

Fred Vermolen

Organisation

Name of the organisation University of Hasselt (UHasselt)

Department Mathematics and Statistics

Country Belgium

SCOPE OF THE METHOD

The Method relates to	Human health
The Method is situated in	Translational - Applied Research
Type of method	In silico
Specify the type of cells/tissues/organs	human skin

DESCRIPTION

Method keywords

mathematical modelling

finite element methods

uncertainty quantification

skin contraction

hypertrophic scar

Scientific area keywords

dermal contraction

fibroblasts
cellular traction forces
momentum balance
morphoelasticity
statistical sampling
uncertainty assessment
stochastic models
partial differential equations

Method description

Severely burned skin can exhibit serious contractions that may negatively impact the mobility of joints of patients. The method deals with post-burn evolution of skin, in which one considers the balance of momentum, cells, collagen and chemokines. The balances are represented in terms of partial differential equations, of which the solution is approximated by the use of numerical techniques. These techniques combine finite element discretization, time integration and root finding problem to solve the resulting nonlinear algebraic equations. Since many of the input parameters are unknown, uncertainty assessment is done in order to obtain output results in terms of estimations of probability distributions. The main output variables are the wound area and total dermal stress energy as a function of time after injury, since these parameters quantify the extent of dermal contraction.

Lab equipment

For this method one only needs a computer with software.

Method status

Still in development
Internally validated
Published in peer reviewed journal

PROS, CONS & FUTURE POTENTIAL

Advantages

- The method is useful for the prediction of skin behavior over time;
- The method is allows results to be interpreted in a probabilistic sense ;

- The method does not need additional animal experiments.

Challenges

- Incorporation of treatments;
- Using machine learning to decrease simulation times.

Modifications

- Implementation of therapies;
- Machine learning to decrease simulation times;
- Improvements in describing the underlying physics.

Future & Other applications

The mathematical method is generic in nature, we expect many principles to be applicable to cancer, diabetic wounds and organ development.

REFERENCES, ASSOCIATED DOCUMENTS AND OTHER INFORMATION

References

G Egberts, FJ Vermolen, PPM van Zuijlen (2023). Stability of a two-dimensional biomorphoelastic model for post-burn contraction. Journal of Mathematical Biology 86 (4): 59

G Egberts, A Desmoulière, FJ Vermolen, PPM van Zuijlen (2023). Sensitivity of a two-dimensional biomorphoelastic model for post-burn contraction. Biomechanics and Modeling in Mechanobiology 22 (1): 105-121

G Egberts, FJ Vermolen, PPM van Zuijlen (2023). High-speed predictions of post-burn contraction using a neural network trained on 2D-finite element simulations. FRONTIERS MEDIA Statistics and Applied Mathematics

Associated documents

Sensitivity of a two-dimensional biomorphoelastic model for post-burn contraction.pdf

s00285-023-01893-w.pdf

High-speed predictions of post-burn contraction using a neural network trained on 2D-finite element simulations.pdf

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